ORIGINAL ARTICLE

The global burden of non-conflict related firearm mortality

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Objective: Understanding global firearm mortality is hindered by data availability, quality, and comparability. This study assesses the adequacy of publicly available data, examines populations for whom firearm mortality data are not publicly available, and estimates the global burden of non-conflict related firearm mortality.

Design: The design is a secondary analysis of existing data. A dataset of countries, populations, economic development, and geographic regions was created, using United Nations 2000 world population data and World Bank classifications of economic development and global regions. Firearm mortality data were obtained from governmental vital statistics reported by the World Health Organization and published survey data. A qualitative review of literature informed estimates for the 15 most populous countries without firearm death data. For countries without data, estimates of firearm deaths were made using quartiles of observed rates and peer reviewed literature.

Main outcome measures: Non-conflict related firearm deaths.

Results: Global non-conflict related firearm deaths were estimated to fall between 196 000 and 229 000, adjusted to the year 2000. 162 800 firearm deaths adjusted for the year 2000 came from countries reporting data and represent 35% of the world's 186 countries. Public data are not available for 122 of these 186 countries, representing more than three billion (54%) of the world's population, predominately in lower and lower middle income countries. Estimates of firearm death for those countries without data range from 33 200 to 66 200.

Conclusions: This study provides evidence that the burden of firearm related mortality poses a substantial threat to local and global health.

Health threats cross national borders and extend beyond infectious disease to include violence.[1][2] The World Health Organization (WHO) *World Report on Violence and Health* (WRVH) urges member nations to examine the impact of intentional injury and develop strategies to reduce violence.[3] Firearm deaths contribute to this burden of violence.[4] In some countries, the firearm is the most frequently used weapon for homicide and suicide.[5][6] Delineating the burden of firearm violence is hindered by data limitations, with international comparisons heavily weighted toward high income countries with well developed vital statistics systems.[7][8] Countries without firearm death data (FDD) are of interest because they account for a large proportion of the world's population.

This study assessed the adequacy of publicly available data, examined populations without FDD, and estimated the global burden of non-conflict related firearm mortality. Conflict related FDD were excluded, not to minimize the importance of conflict related deaths, but to establish a baseline of global firearm mortality, independent of armed conflict.

METHODS

We compiled a country level dataset of reported FDD from existing public sources, projected these data to the year 2000, assessed and adjusted for missing data on intent, and conducted a literature review to develop estimates of firearm deaths for countries without FDD. These data were compiled for 186 countries with populations greater than 140 000 persons.[9]

Data sources

Firearm deaths by intent for the latest year reported (1994–2000) were assembled from the WHO-WRVH[3] and two surveys.[6][10] These data, based on international cause of death coding, exclude military/police action and conflict related firearm deaths. The WHO dataset consists of vital statistics data reported from 100 countries. Country level survey data were obtained from the United Nation's (UN) International Study on Firearm Regulations report and online database, with responses from 69 member nations.[10] A third data source was a survey of health officials from 36 high/upper middle income countries with populations greater than one million.[8] With these data we could not adjust for overall underreporting of deaths or age/sex specific rates. For comparability, firearm deaths were projected to UN year 2000 population estimates.[9]

Categories of data availability

Sources for FDD were prioritized (fig 1). The primary class is the WHO-WRVH data, representing 42 countries with a combined population of 1 053 658 000. The second data class—survey data with complete intent categories—adds 12 countries with a population of 390 438 000. The final data class—survey data with missing intent categories—adds 10 countries with a population of 1 342 227 000. Total crude firearm death rates (CFDR), percent of intentional injury deaths caused by firearms, and the proportionate share of the world's population were calculated for each class of data availability. Percent of population with FDD and CFDRs were calculated by economic development level and region. We conducted a detailed examination on the 15 most populous countries with FDD and the 15 most populous countries without FDD. These 30 countries account for nearly 80% of the world's population.

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Abbreviations: CFDR, crude firearm death rates; FDD, firearm death data; UN, United Nations; WHO, World Health Organization; WRVH, World Report on Violence and Health.
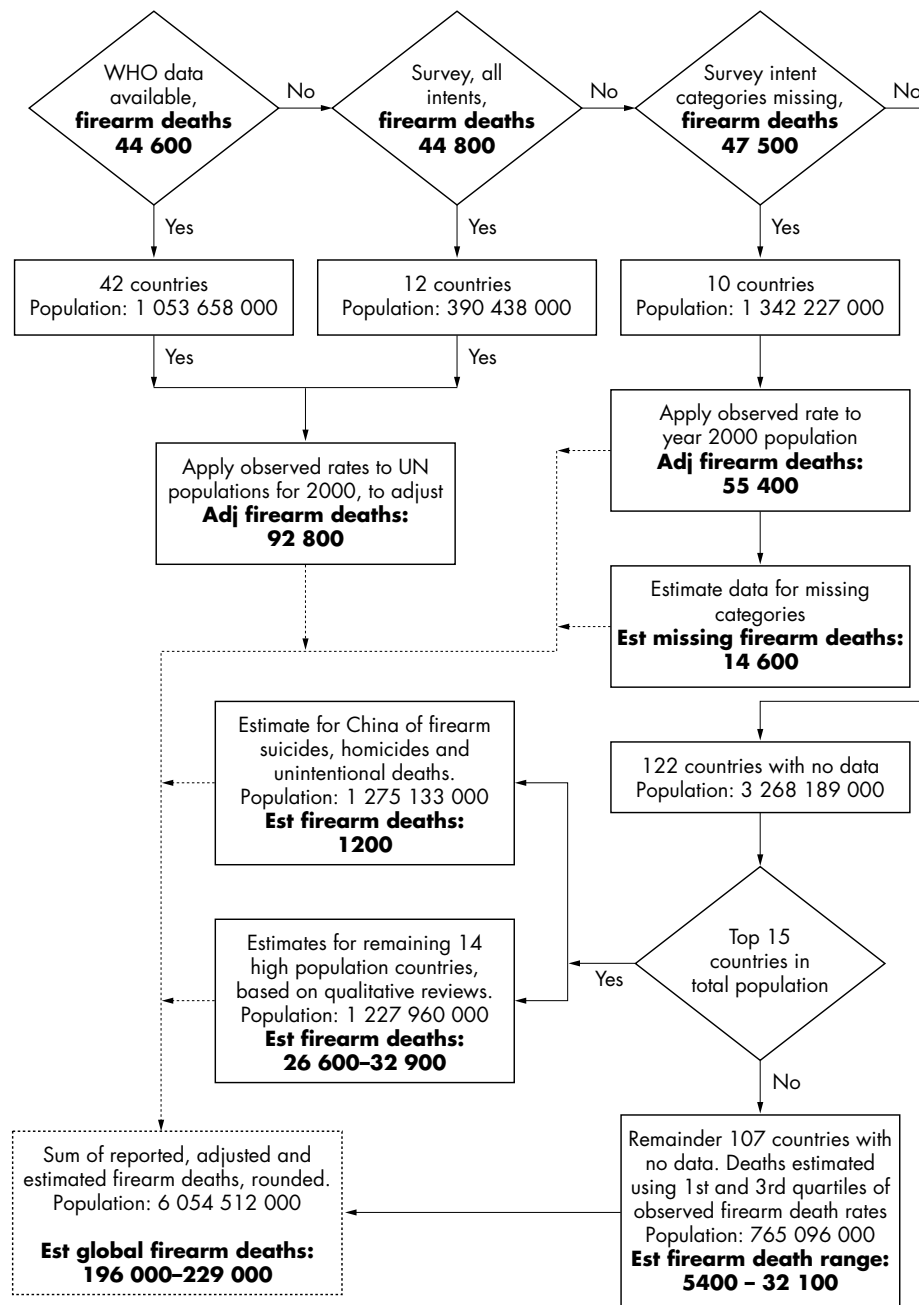
Figure 1 Data categories, 2000 populations, and estimated firearm deaths.

Estimates for countries with FDD

We projected deaths to the year 2000 for the 64 countries with available data using observed CFDRs. We adjusted total FDD, by using observed ratios of firearm deaths between intent categories from countries with complete data to solve for missing categories in the 10 (of 64) countries with incomplete intent categories. An average unintentional and undetermined CFDR of 0.36 per 100 000 was used to estimate these missing deaths.

Estimates for countries without FDD

We explored several methods for estimating firearm mortality for the 122 countries without FDD. As others have used region and/or income level to build global estimates,[11] we examined available data by region and economic development level, using World Bank categories.[12] [13] We found wide variation in firearm death rates within and between economic levels and regions, and small cell sizes within some region/economic classes. Populations without reported FDD are disproportionately located in lower middle/lower income countries (see http://www.injuryprevention.com/supplemental for economic level and region data) Therefore, we chose to use data from a number of sources to calculate a global estimate.

Two approaches were used: qualitative literature review and estimation for the 15 most populous countries without FDD (with China handled separately), and application of high and low quartile death rates for the remaining 107 countries.

The literature review used electronic search engines, followed by hand searches of bibliographic references or web page content. Local vital statistics data, allowing the computation of rates, were considered best, though not nationally representative. Death review data (for example,

Table 1 Fifteen most populous countries and reported firearm deaths

Most populous countries with FDD (firearm death data year)source	CFDR/100000 population	Reported firearm deaths, projected to year 2000 population*	% of intentional deaths by firearm
India (1994)s2	0.3	3300*	–
United States (1998)w	10.9	30900	63.0
Brazil (1995)s1	26.7	45500	96.5
Japan (1997)w	0.1	100	0.0
Mexico (1994)s2	12.1	12000*	61.3
Germany (1999)w	1.5	1200	12.7
Viet Nam (1995)s1	0.2	100	–
Philippines (1996)s2	3.6	2700*	22.8
Thailand (1994)w	4.3	2700	36.7
United Kingdom (1999)w	0.3	200	4.4
France (1998)w	5.0	3000	32.5
Italy (1997)w	2.0	1200	27.9
Republic of Korea (1997)w	0.1	100	0.9
South Africa (1995)s2	27.0	11700*	–
Colombia (1995)s2	51.9	21800*	79.8
Total	5.9	136400	56.9

Source: w = WHO-WRVH; s1 = survey, all intents, s2 = survey, missing intents.
*Reported firearm deaths for S2 countries, which by definition do not include all intent categories and therefore underestimate total firearm deaths.

autopsies, trauma data) have significant biases, but help estimate the proportion of firearm deaths. Other data sources (for example, key informant estimates; community survey) provide only broad indications of firearm deaths.

China was treated separately from the other populous countries without FDD, based on evidence of extremely low rates coupled with a large population. A review of suicide studies for select areas in China[14] provides an estimate of 0.56% of suicides by firearm, which could be applied to reported suicide death rates for selected urban and rural areas of China (13.7/100 000).[3] Linear regression was used to predict percent homicides by firearm (95% CI 0.54 to 0.97%), based on observed percent firearm for homicides and suicides among countries with FDD, and applied to reported homicide rates for selected urban/rural areas of China (1.8/100 000).[3] Unintentional/underdetermined firearm deaths were estimated as 5.7% of all intentional firearm deaths, based on the ratio observed in the 54 countries reporting all intent categories.

For the remaining 14 most populous countries without data, the literature review was used to classify countries to low, medium, or high firearm mortality rates. As the distribution of the firearm death rates for the 54 countries with complete FDD was strongly skewed, we used the first (0.7/100 000), second (2.0/100 000), or third quartiles (4.2/100 000) to quantify estimates of low, medium, or high firearm death rates, rather than the mean. Four of the most populous countries without FDD had areas of armed conflicts (Indonesia, Democratic Republic of Congo, Nigeria, Sudan). We did not attempt to estimate conflict related firearm deaths, but studies of civilian-on-civilian injuries indicate that firearm mortality in these countries is likely to be high. For the three of these 15 countries without qualitative evidence (Egypt, Ethiopia, Myanmar) and the remaining 107 countries without FDD, first and third quartiles were applied to their year 2000 population.

RESULTS

The global burden of non-conflict related firearm mortality is estimated at 196 000 to 229 000 per year (fig 1). Firearm mortality for countries with WHO-WRVH vital statistics and from published surveys of government officials, once adjusted to the year 2000, yielded 92 800 deaths, covering 23.8% of the world's population. Adding adjusted survey data from the 10 additional countries with missing intent categories added another 70 000 firearm deaths. In total, these three data sources yielded 162 800 firearm deaths for the year 2000 and represent 35% (64/186 countries) of

Table 2 Fifteen most populous countries not reporting firearm deaths

Most populous countries without FDD	Population	Estimated* CFDR/100000 based on qualitative information	Estimated firearm deaths, based on qualitative information
China	1275133000	0.1	1200
Indonesia	212092000	0.7	1500
Russian Federation	145491000	0.7	3000
Pakistan	141256000	4.2	5900
Bangladesh	137439000	4.2	5800
Nigeria	113862000	2.0	2300
Iran	70330000	0.7	500
Egypt	67884000	0.7–4.2	500–2900
Turkey	66668000	2.0	1400
Ethiopia	62908000	0.7–4.2	400–2600
Democratic Republic of Congo	50948000	4.2	2100
Ukraine	49568000	0.7	300
Myanmar	47749000	0.7–4.2	300–2000
Sudan	31095000	4.2	1300
Kenya	30669000	4.2	1300
Total	2503093000		27800–34100

Extremely low = 0.1; low (Q1) = 0.7; medium (Q2) = 2.0; high (Q3) = 4.2.

potential reporting entities and 46% of the world's population.

Countries reporting FDD

The 15 most populous countries reporting FDD cover a population exceeding two billion (37.9% of world population), accounting for 92.0% of reported global firearm deaths (table 1). CFDRs vary substantially. Colombia, South Africa, Brazil, United States, and Mexico have the highest CFDRs and the greatest number of firearm deaths.

Countries not reporting FDD

The 15 most populous countries not reporting FDD cover a population exceeding 2.6 billion (41.3% of world population) and represent 76.5% of the total global population without FDD (15/122 countries) (table 2). The publication review provided empirical evidence of the presence and magnitude of firearm death (see http://www.injuryprevention.com/supplemental for detailed table and sources). Reports based on autopsy, ambulance, and hospital data provided evidence on local firearm injury or deaths.[15][16] For others, surveys provided indications of firearm violence.[17][18] Evidence for China indicates an extremely low rate, based upon intentional death rates for selected areas[19] and a meta-review of 13 studies reporting the percent of suicide by firearm.[14] Our estimates for the 15 most populous countries without data yielded an estimate range of 27 800 to 34 100, and our estimates for the remaining 107 countries without data range from 5400 to 32 100.

DISCUSSION
Key findings

The global burden of firearm mortality is estimated to be 196 000 to 229 000. This analysis extends beyond international comparisons of firearm mortality typically limited to higher income countries.[20–24] Missing FDD for many lower income countries and populations in the Middle East, sub-Saharan Africa, and East Asia, create biases.[20][21] By combining countries with FDD from vital statistics and from other data of varying levels of completeness, our estimate covers substantially more of the world's population.

Study strengths and limitations

Our approach to informing the estimates of the 15 most populous countries without FDD incorporated new data from a variety of sources. As these countries represent 76.5% of the populations without FDD, published literature for these countries is an important resource.[6][25] Readers can easily update our global estimate as new data become available. Our estimates used publicly available health data and publications or abstracts available in English. Although it is difficult to validate our approach, our similar yet tighter estimates than the Small Arms Survey findings lends credibility to our estimations.[11] The Small Arms Survey provides an estimate of 200 000–270 000 with some differences in data sources and analytic techniques.[11]

Combining available sources and making estimates for missing data provide more comprehensive population coverage, at the expense of some precision. Even with reported FDD, incomplete death or population coverage can result in under or overreporting for regions (for example, rural) or people (for example, stigmatized deaths or marginalized groups). Survey responses may be biased for countries with greater interest in firearm deaths. The effects of underreporting in published data may downward bias both reported and estimated deaths.

Projecting reported FDD rates to the year 2000 population assumes a constant rate of firearm death, although temporal variations are to be expected. Recent data, external to our dataset, illustrate the potential impact. For example, United States data indicate approximately 2000 fewer deaths than our estimate, while qualitative evidence indicates increasing firearm deaths in some countries without data (for example, Russian Federation).[7][26] A recent report on firearm deaths in Brazil identifies changes in data quality, which suggests lower estimates for year 2000 firearm deaths than reported here.[27]

Conflict related mortality

We excluded conflict related mortality (as distinct ICD codes) in this analysis. Yet conflict affects non-conflict related firearm deaths, which can increase with the influx and residual presence of firearms.[28] Military weapons can move rapidly into civilian sectors and illegal transport, importation, and availability of firearms is a problem on all continents.[10][29] Evidence suggests that small arms left behind from conflicts do cause injuries in countries without FDD.[30–34]

Recommendations

Three major recommendations stem from this study: improve data, recognize the burden of firearm mortality, and take public health action. Improving surveillance, data availability, and specificity are important; however this requires government and social stability, financial investment, infrastructure, and human resource commitment.[35][36] Proper classification of deaths from firearm violence requires more complex systems, incorporating both mechanism and intent. Where government vital statistics collection is not feasible, surveillance or descriptive data from other sources become increasingly important. Adding other approaches to traditional surveillance systems—such as surveys, hospital and emergency transport data, and humanitarian aid and mortuary data—has much to offer.[14][15][19][28][36] Although limited in scope, these types of data can help identify trends in firearm injury and death and better portray the local and regional burden.

The local and global health burden of firearm mortality is clear and compelling. Over the next two decades the absolute number of firearm deaths will increase as populations at risk continue to grow, particularly in lower income countries without FDD. Global demographic shifts in urbanization and poverty could increase risks for firearm violence.[1] In addition, the worldwide proliferation of small arms and their diffusion into civilian populations seem to make this escalation of global firearm violence inevitable.[30][31]

Public health action is important, although the science on effective prevention programs is limited.[37] Building a better empirical foundation for addressing the sociocultural and economic environments that enhance or mitigate the potential for firearm death should be an international effort. The high variability of firearm death rates provides a valuable opportunity to use cross national comparisons to explore and better understand risk factors.[38] Analysis of the effects of firearm availability and legislative approaches to firearm violence on the health of citizens are often limited to countries with FDD.[23][24][39] These policies include firearm and ammunition designs, manufacturing and distribution, access to firearms (legal limitations and strategies to address firearms left behind in regional conflict), import and export controls, and offender access. Such information and experience could guide the world health community and individual countries in developing effective responses to firearm injury.

Firearm related mortality must be viewed as a health problem of substantial burden, which extends beyond national borders and is dynamic in nature. The world health community can take action to improve global understanding and make policy recommendations that begin to address the complex series of events that result in firearm injury.

Key points

- Global non-conflict firearm deaths are estimated to be 196 000 to 229 000.
- Countries with the most complete firearm data covered only 23.8% of the world's population.
- The distribution of populations without reported firearm death data are disproportionately located in lower middle and lower income countries.
- Total firearm deaths for the 15 most populous countries without reported data are estimated to be 27 800 to 34 100 deaths per year.

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